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ITU-T

G.708

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(03/93)

GENERAL ASPECTS OF DIGITAL TRANSMISSION SYSTEMS

NETWORK NODE INTERFACE FOR THE SYNCHRONOUS DIGITAL HIERARCHY

ITU-T Recommendation G.708

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation G.708 was revised by the ITU-T Study Group XVIII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

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NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

CONTENTS

Recommendation G.708

NETWORK NODE INTERFACE FOR THE SYNCHRONOUS DIGITAL HIERARCHY

(Melbourne, 1988; revised Geneva, 1991 and Helsinki, 1993)

The CCITT,

considering

(a) that Network node interface (NNI) specifications are necessary to enable interconnection of synchronous digital network elements for transport of payloads, including digital signals of the Plesiochronous digital hierarchy (PDH) defined in Recommendation G.702;

(b) that Recommendation G.707 describes the advantages offered by a synchronous digital hierarchy and multiplexing method and specifies a set of synchronous digital hierarchy bit rates;

(c) that Recommendation G.709 specifies the multiplexing structure;

(d) that Recommendations G.707, G.708 and G.709 form a coherent set of specifications for the synchronous digital hierarchy and network node interface;

(e) that Recommendation G.802 specifies the interworking between networks based on different plesiochronous digital hierarchies and speech encoding laws,

recommends

that the frame structure for multiplexed digital signals at the NNI of a synchronous digital network including ISDN should be as described in this Recommendation.

1 General

1.1 Abbreviations

For the purpose of this Recommendation the following abbreviations are used:

APS automatic protection switching

AU-n administrative unit-n

AUG administrative unit group

BIP-X bit interleaved parity-X

DCC data communication channel

ISDN integrated services digital network

MS-AIS multiplex section alarm indication signal

MS-FERF multiplex section far end receive failure

MSOH multiplex section overhead

NNI network node interface

PDH plesiochronous digital hierarchy

POH path overhead

RSOH regenerator section overhead

SDH synchronous digital hierarchy

SOH section overhead

STM(-N) synchronous transport module (-N)

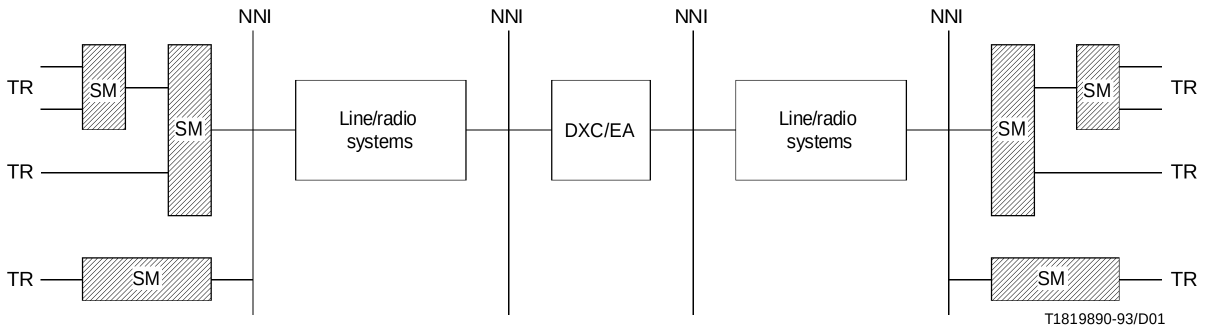
TU-n tributary unit-n

TUG(-n) tributary unit group (-n)

VC-n virtual container-n

1.2 Location of NNI

Figure 1-1 gives a possible network configuration to illustrate the location of NNI specified in this Recommendation.



DXC Digital cross-connect equipment
EA External access equipment
SM Synchronous multiplexer
TR Tributaries

FIGURE 1-1/G.708

Location of the NNI

2 Basic multiplexing principle and multiplexing elements

2.1 General

Figure 2-1 shows the relationship between various multiplexing elements that are defined below, and illustrates possible multiplexing structures.

Figures 2-2, 2-3, 2-4 and 2-5 are examples of how various signals are multiplexed using these multiplexing elements.

Details of the multiplexing method and mappings are given in Recommendation G.709.

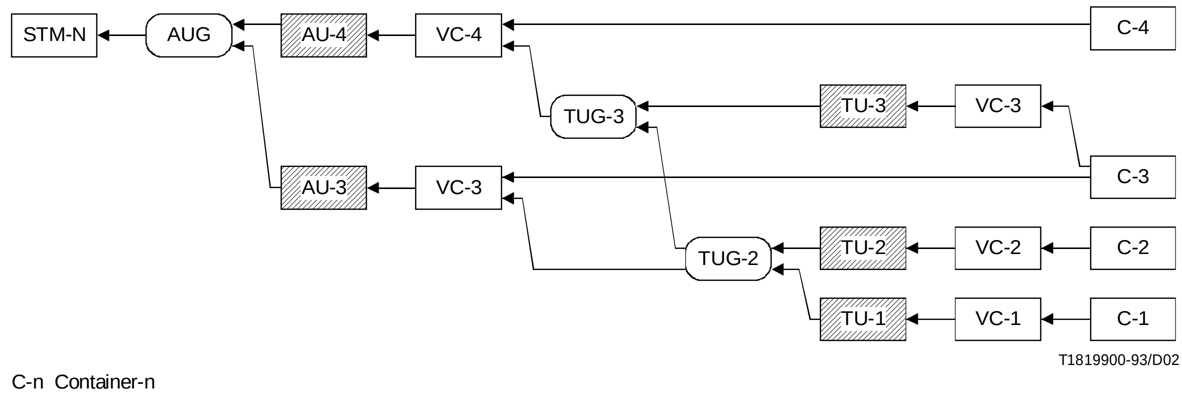
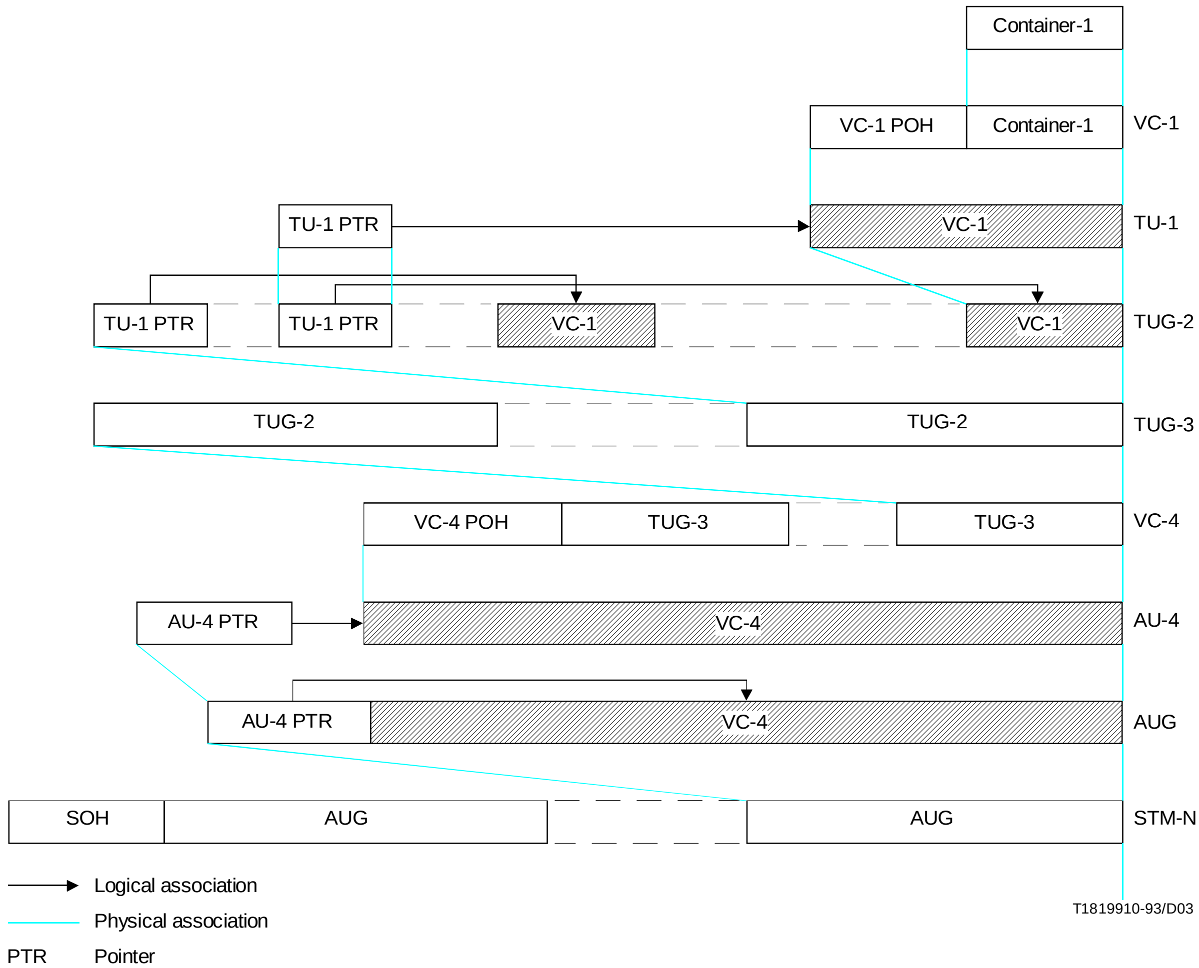


FIGURE 2-1/G.708

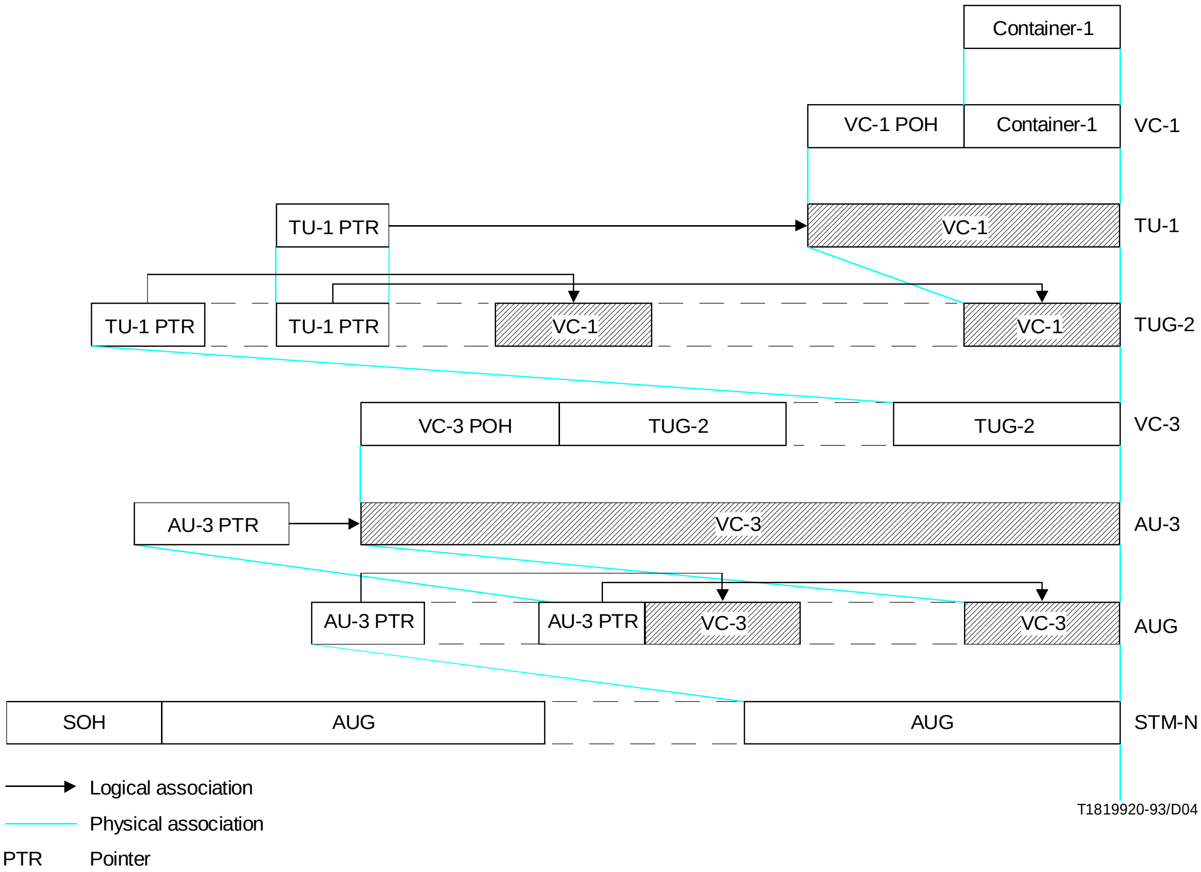
Generalized multiplexing structure



NOTE – Unshaded areas are phase aligned. Phase alignment between the unshaded and shaded areas is defined by the pointer (PTR) and is indicated by the arrow.

FIGURE 2-2/G.708

Multiplexing method directly from container-1 using AU-4



NOTE – Unshaded areas are phase aligned. Phase alignment between the unshaded and shaded areas is defined by the pointer (PTR) and is indicated by the arrow.

FIGURE 2-3/G.708

Multiplexing method directly from container-1 using AU-3

2.2 Definitions

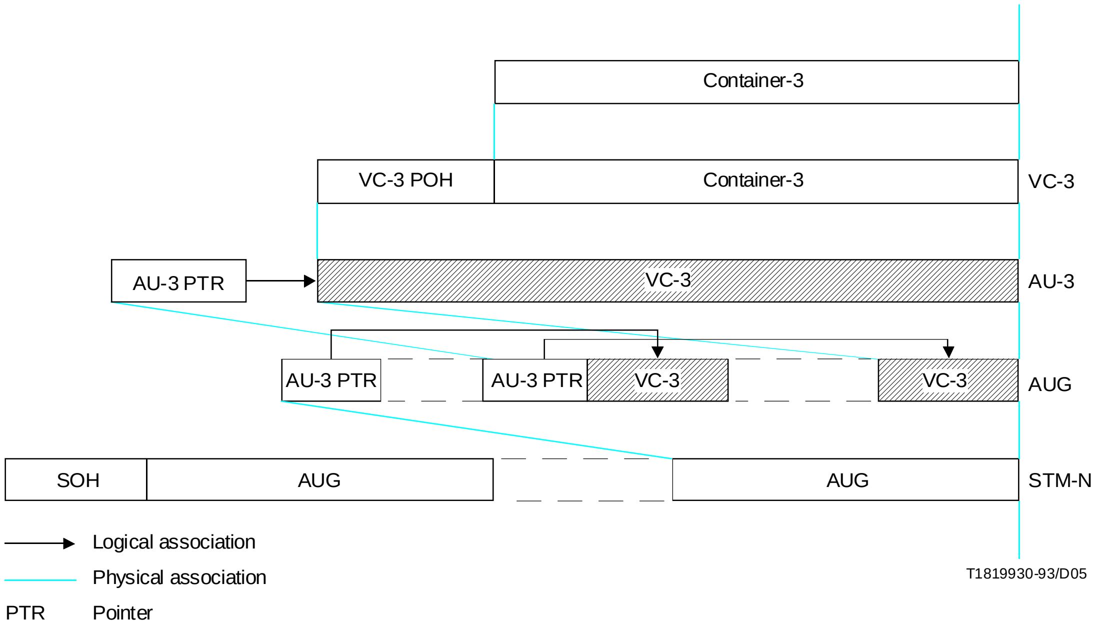
For the purpose of this Recommendation the following abbreviations are used:

2.2.1 synchronous digital hierarchy (SDH): the SDH is a hierarchical set of digital transport structures, standardised for the transport of suitably adapted payloads over physical transmission networks.

2.2.2 synchronous transport module (STM): an STM is the information structure used to support section layer connections in the SDH. It consists of information payload and section overhead (SOH) information fields organised in a block frame structure which repeats every 125 microseconds. The information is suitably conditioned for serial transmission on the selected media at a rate which is synchronised to the network. A basic STM is defined at 155 520 kbit/s. This is termed STM-1. Higher capacity STMs are formed at rates equivalent to *N* times multiples of this basic rate. STM capacities for $N = 4$ and $N = 16$ are defined; higher values are under consideration.

The STM-1 comprises a single administrative unit group (AUG) together with the SOH.

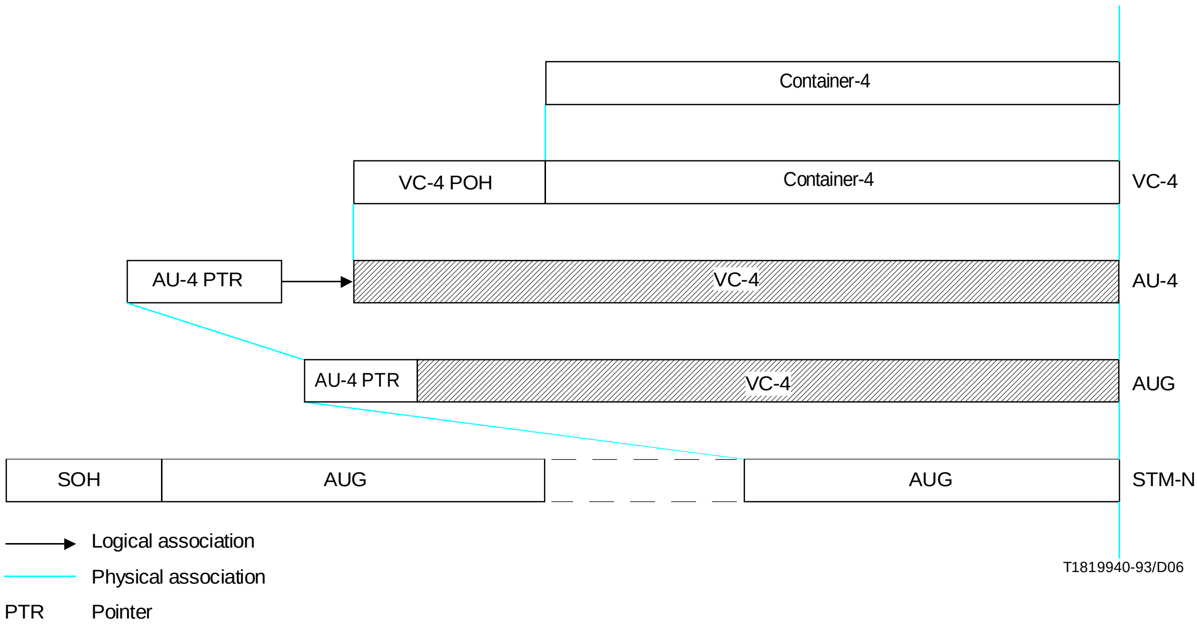
The STM-N contains *N* AUGs together with SOH. Values of *N* corresponding to the SDH levels are given in Recommendation G.707.



NOTE – Unshaded areas are phase aligned. Phase alignment between the unshaded and shaded areas is defined by the pointer (PTR) and is indicated by the arrow.

FIGURE 2-4/G.708

Multiplexing method directly from container-3 using AU-3



NOTE – Unshaded areas are phase aligned. Phase alignment between the unshaded and shaded areas is defined by the pointer (PTR) and is indicated by the arrow.

FIGURE 2-5/G.708

Multiplexing method directly from container-4 using AU-4

2.2.3 virtual container-*n* (VC-*n*): a virtual container is the information structure used to support path layer connections in the SDH. It consists of information payload and path overhead (POH) information fields organised in a block frame structure which repeats every 125 or 500 microseconds. Alignment information to identify VC-*n* frame start is provided by the server network layer.

Two types of virtual containers have been identified.

– Lower order virtual container-*n*: VC-*n* (*n* = 1, 2)

  This element comprises a single container-*n* (*n* = 1, 2) plus the lower order virtual container POH appropriate to that level.

– Higher order virtual Container-*n*: VC-*n* (*n* = 3, 4)

  This element comprises either a single container-*n* (*n* = 3, 4) or an assembly of tributary unit groups (TUG-2s or TUG-3s), together with virtual container POH appropriate to that level.

2.2.4 administrative unit-*n*: AU-*n*: an administrative unit is the information structure which provides adaptation between the higher order path layer and the multiplex section layer. It consists of an information payload (the higher order virtual container) and an administrative unit pointer which indicates the offset of the payload frame start relative to the multiplex section frame start.

Two administrative units are defined. The AU-4 consists of a VC-4 plus an administrative unit pointer which indicates the phase alignment of the VC-4 with respect to the STM-N frame. The AU-3 consists of a VC-3 plus an administrative unit pointer which indicates the phase alignment of the VC-3 with respect to the STM-N frame. In each case the administrative unit pointer location is fixed with respect to the STM-N frame.

One or more administrative units occupying fixed, defined positions in an STM payload is termed an administrative unit group (AUG).

An AUG consists of a homogeneous assembly of AU-3s or an AU-4.

2.2.5 tributary unit-*n*: TU-*n*: a tributary unit is an information structure which provides adaptation between the lower order path layer and the higher order path layer. It consists of an information payload (the lower order virtual container) and a tributary unit pointer which indicates the offset of the payload frame start relative to the higher order virtual container frame start.

The TU-*n* (*n* = 1, 2, 3) consists of a VC-*n* together with a tributary unit pointer.

One or more tributary units, occupying fixed, defined positions in a higher order VC-*n* payload is termed a tributary unit group (TUG). TUGs are defined in such a way that mixed capacity payloads made up of different size tributary units can be constructed to increase flexibility of the transport network.

A TUG-2 consists of a homogeneous assembly of identical TU-1s or a TU-2.

A TUG-3 consists of a homogeneous assembly of TUG-2s or a TU-3.

2.2.6 container-*n* (*n* = 1-4): a container is the information structure which forms the network synchronous information payload for a virtual container. For each of the defined virtual containers there is a corresponding container. Adaptation functions have been defined for many common network rates into a limited number of standard containers. These include those rates already defined in Recommendation G.702. Further adaptation functions will be defined in the future for new broadband rates.

2.2.7 network node interface (NNI): the interface at a network node which is used to interconnect with another network node.

NOTE – The above definition is a working definition only; the precise definition is for further study.

2.2.8 pointer: an indicator whose value defines the frame offset of a virtual container with respect to the frame reference of the transport entity on which it is supported.

2.2.9 concatenation: a procedure whereby a multiplicity of virtual containers is associated one with another with the result that their combined capacity can be used as a single container across which bit sequence integrity is maintained.

2.2.10 **SDH mapping**: a procedure by which tributaries are adapted into virtual containers at the boundary of an SDH network.

2.2.11 **SDH multiplexing**: a procedure by which multiple lower order path layer signals are adapted into a higher order path or the multiple higher order path layer signals are adapted into a multiplex section.

2.2.12 **SDH aligning**: a procedure by which the frame offset information is incorporated into the tributary unit or the administrative unit when adapting to the frame reference of the supporting layer.

3 Frame structure

3.1 Basic frame structure

STM-N frame structure is shown in Figure 3.1. The three main areas of the STM-N frame are indicated

- SOH;
- administrative unit pointer(s)
- information payload.

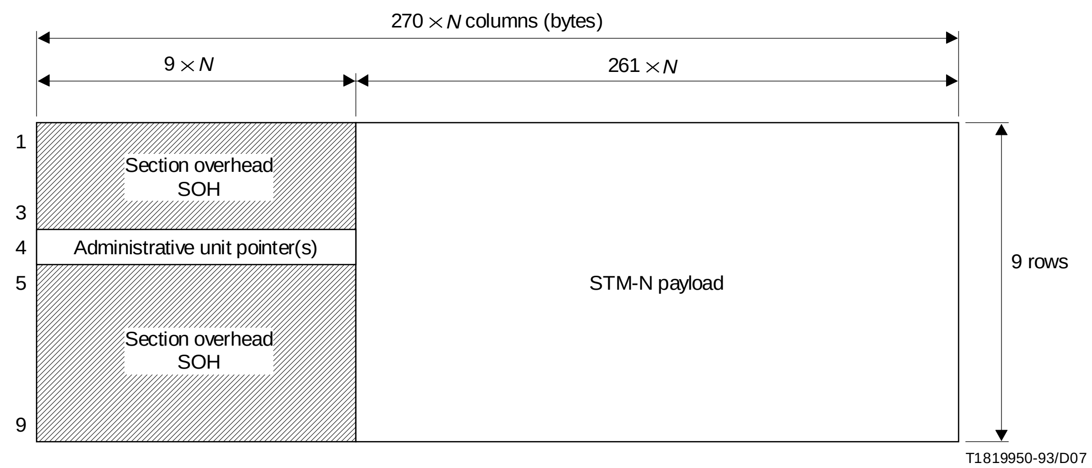


FIGURE 3-1/G.708

STM-N frame structure

3.2 Section overhead

Rows 1-3 and 5-9 of columns 1 to 9 $\times$ N of the STM-N in Figure 3-1 are dedicated to the SOH.

The allocation of SOH capacity and an explanation of the overhead functions are given in 5.

3.3 Administrative unit pointers

Row 4, of columns 1 to 9 $\times$ N in Figure 3-1, is available for administrative unit pointers. The application of pointers and their detailed specifications are given in Recommendation G.709.

3.4 Administrative units in the STM-N

The STM-N payload can support *N* AUGs where each AUG may consist of

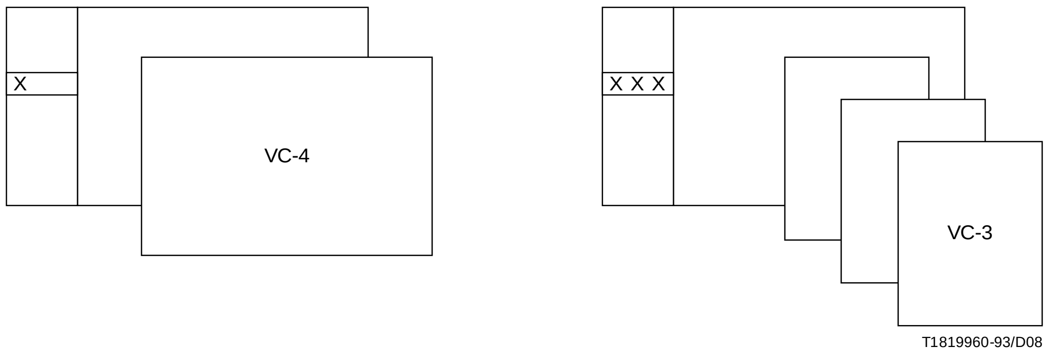
– one AU-4; or

– three AU-3s.

The VC-*n* associated with each AU-*n* does not have a fixed phase with respect to the STM-N frame. The location of the first byte of the VC-*n* is indicated by the AU-*n* pointer. The AU-*n* pointer is in a fixed location in the STM-N frame. Examples are illustrated in Figures 2-2, 2-3, 2-4, 2-5, 3-1, 3-2 and 3-3.

The AU-4 may be used to carry, via the VC-4, a number of TU-*n*s (*n* = 1, 2, 3) forming a two stage multiplex. An example of this arrangement is illustrated in Figures 2-2 and 3-3a). The VC-*n* associated with each TU-*n* does not have a fixed phase relationship with respect to the start of the VC-4. The TU-*n* pointer is in a fixed location in the VC-4 and the location of the first byte of the VC-*n* is indicated by the TU-*n* pointer.

The AU-3 may be used to carry, via the VC-3, a number of TU-*n*s (*n* = 1, 2) forming a two stage multiplex. An example of this arrangement is illustrated in Figures 2-3 and 3-3b). The VC-*n* associated with each TU-*n* does not have a fixed phase relationship with respect to the start of the VC-3. The TU-*n* pointer is in a fixed location in the VC-3 and the location of the first byte of the VC-*n* is indicated by the TU-*n* pointer.



a) STM-1 with one AU-4 **b) STM-1 with three AU-3s**

X AU-*n* pointer
AU-*n* AU-*n* pointer + VC-*n* (see 2)

FIGURE 3-2/G.708

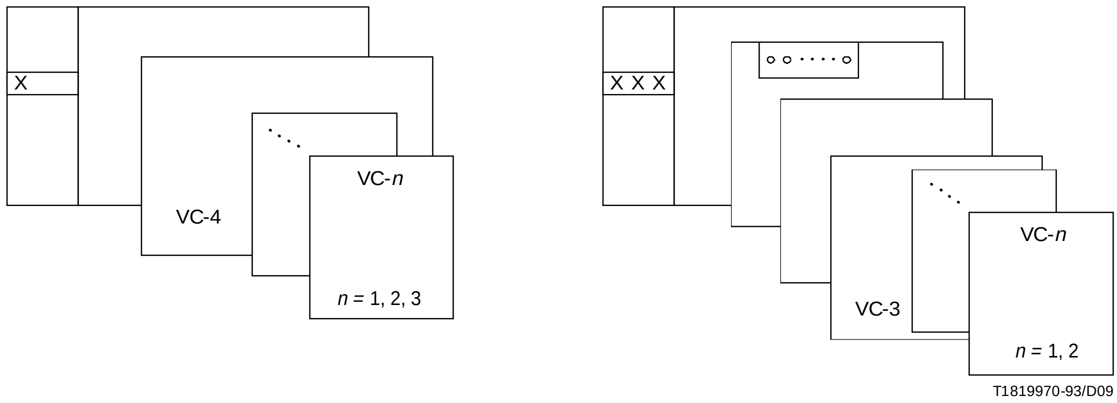
Administrative units in STM-1 frame

4 Interconnection of STM-Ns

The SDH is designed to be universal, allowing transport of a large variety of signals including all those specified In Recommendation G.702. However, different structures can be used for the transport of virtual containers. The following interconnection rules will be used :

a) The rule for interconnecting two AUGs based upon two different types of administrative unit, namely AU-4 and AU-3, will be to use the AU-4 structure. Therefore, the AUG based upon AU-3 will be demultiplexed to the TUG-2 or VC-3 level according to the type of the payload, and remultiplexed within an AUG via the TUG-3/VC-4/AU-4 route.

b) The rule for interconnecting VC-11s is transported via different types of tributary unit, namely TU-11 and TU-12 will be to use the TU-11 structure. VC-11, TU-11 and TU-12 are described in Recommendation G.709.



a) STM-1 with one AU-4 containing TUs

b) STM-1 with three AU-3s containing TUs

X AU-*n* pointer
o TU-*n* pointer
AU-*n* AU-*n* pointer + VC-*n* (see 2)
TU-*n* TU-*n* pointer + VC-*n* (see 2)

FIGURE 3-3/G.708

Two stage multiplex

This SDH interconnection rule does not modify the interworking rules defined in Recommendation G.802 for networks based upon different plesiochronous digital hierarchies and speech encoding laws.

NOTE – The need for specifying rules for interconnection between networks using different types of concatenation (see 3.3.7/G.709) is for further study.

5 Overhead functions

5.1 Types of overhead

Several types of overhead have been identified for application in the SDH.

5.1.1 SOH

SOH information is added to the information payload to create an STM-N. It includes block framing information and information for maintenance, performance monitoring and other operational functions. The SOH information is further classified into regenerator section overhead (RSOH) which is terminated at regenerator functions and multiplex section overhead (MSOH) which passes transparently through regenerators and is terminated where the AUGs are assembled and disassembled.

The rows 1-3 of the SOH are designated as RSOH while rows 5-9 are designated to be MSOH. This is illustrated in Figure 5-2 for the case of STM-1.

5.1.2 Virtual container POH

Virtual container POH provides for integrity of communication between the point of assembly of a virtual container and its point of disassembly. Two categories of virtual container POH have been identified:

– *Lower order virtual container POH (VC-l/VC-2 POH)*

  Lower order VC POH is added to the container (container-l/container-2) when the VC-l/VC-2 is created. Among the functions included in this overhead are Virtual Container path performance monitoring, signals for maintenance purposes and alarm status indications.

– *Higher order virtual container POH (VC-3/VC-4 POH)*

  VC-3 POH is added to either an assembly of TUG-2s or a container-3 to form a VC-3. VC-4 POH is added to either an assembly of TUG-3s or a Container-4 to form a VC-4. Amongst the functions included within this overhead are virtual container path performance monitoring, alarm status indications, signals for maintenance purposes and multiplex structure indications (VC-3/VC-4 composition).

POH descriptions are contained in Recommendation G.709.

5.2 SOH descriptions

5.2.1 SOH bytes location

The location of SOH bytes within an STM-N frame is identified by a three coordinate vector S(a, b, c) where a(l to 3, 5 to 9) represents the row number, b(l to 9) represents a multi-column number and c(l to N) represents the depth of the interleaved within the multi-column. This is illustrated in Figure 5-1.

For example the K1 byte in an STM-1 is located at S (5, 4, 1).

The assignment of the various SOH bytes in the STM-1/4/16 frames is illustrated in Figures 5-2, 5-3 and 5-4.

The relationship between the row and column numbers and the coordinates is given by:

ROW = a

COL = $N(b-1) + c$

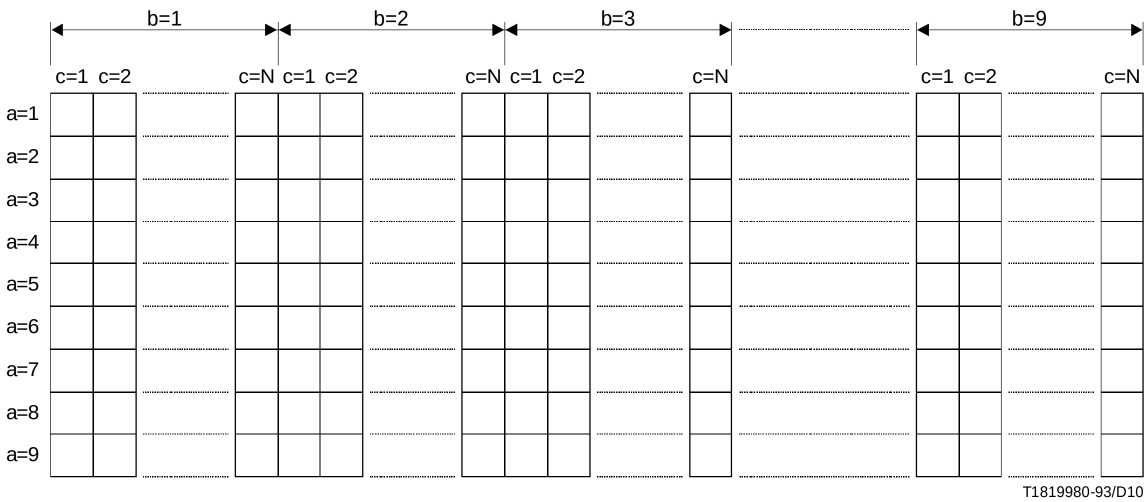
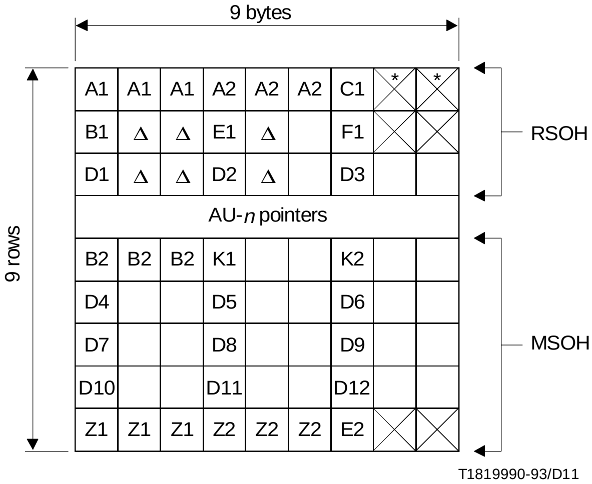


FIGURE 5-1/G.708

Numbering of SOH byte locations for STM-N



Bytes reserved for national use

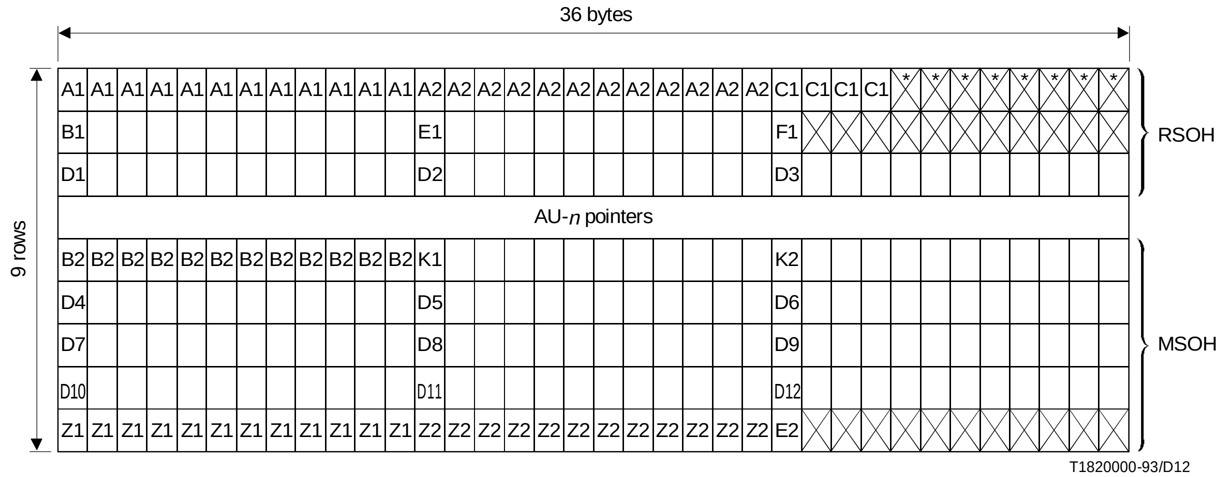
* Unscrambled bytes. Therefore care should be taken with their content

Δ Media dependent bytes

NOTE – All unmarked bytes are reserved for future international standardization (for media dependent, additional national use and other purposes).

FIGURE 5-2/G.708

STM-1 SOH



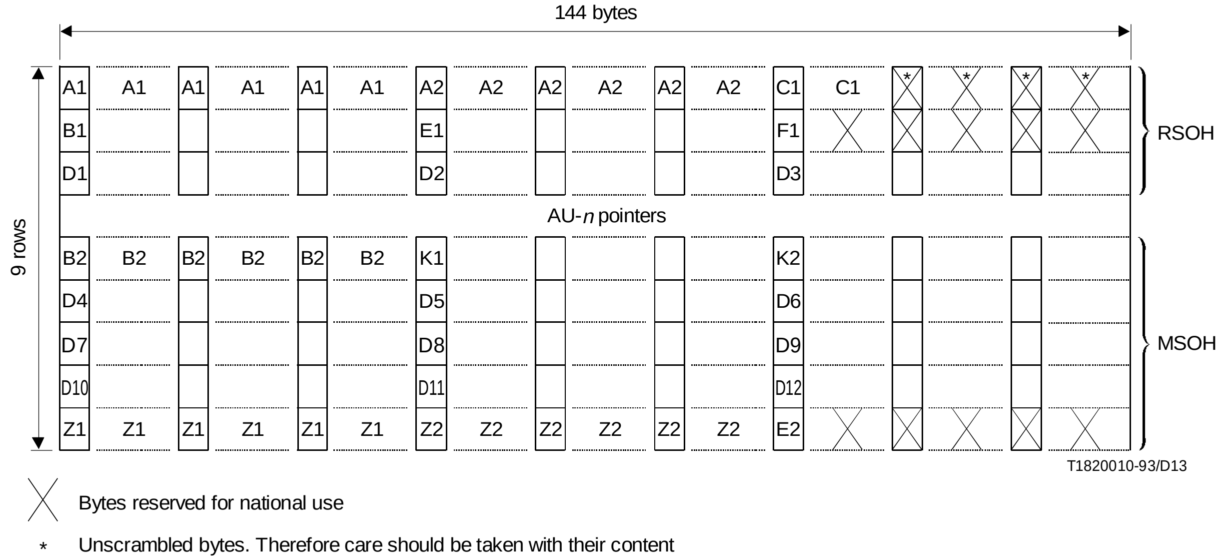
Bytes reserved for national use

* Unscrambled bytes. Therefore care should be taken with their content

NOTE – All unmarked bytes are reserved for future international standardization (for media dependent, additional national use and other purposes).

FIGURE 5-3/G.708

STM-4 SOH



NOTE – All unmarked bytes are reserved for future international standardization (for media dependent, additional national use and other purposes).

FIGURE 5-4/G.708

STM-16 SOH

5.2.2 SOH bytes description

5.2.2.1 Framing: Al A2

Two types of bytes are defined for framing

Al: 1 1 1 1 0 1 1 0

A2: 0 0 1 0 1 0 0 0

5.2.2.2 STM identifier: C1

This is a unique identifier indicating the binary value of the multi-column, interleave depth coordinate, c. It may be used to assist in frame alignment.

5.2.2.3 Data Communication Channel (DCC): D1-D12

A 192 kbit/s channel is defined using bytes Dl, D2 and D3 as a regenerator section DCC.

A 576 kbit/s channel is defined using bytes D4 to Dl2 as a multiplex section DCC.

5.2.2.4 Orderwire: El, E2

These two bytes may be used to provide orderwire channels for voice communication. El is part of the RSOH and may be accessed at regenerators. E2 is part of the MSOH and, may be accessed at multiplex section terminations.

5.2.2.5 User channel: Fl

This byte is reserved for user purposes (e.g. to provide temporary data/voice channel connections for special maintenance purposes).

5.2.2.6 BIP-8: B1

One byte is allocated for regenerator section error monitoring. This function shall be a Bit Interleaved Parity 8 (BIP-8) code using even parity. The BIP-8 is computed over all bits of the previous STM-N frame after scrambling and is placed in byte B1 before scrambling. (For details of the scrambling process see Recommendation G.709).

NOTE – Bit Interleaved Parity-X (BIP-X) code is defined as a method of error monitoring. With even parity an X bit code is generated by the transmitting equipment over a specified portion of the signal in such a manner that the first bit of the code provides even parity over the first bit of all X-bit sequences in the covered portion of the signal, the second bit provides even parity over the second bit of all X-bit sequences within the specified portion, etc. Even parity is generated by setting the BIP-X bits so that there is an even number of 1s in each monitored partition of the signal. A monitored partition comprises all bits which are in the same bit position within the X-bit sequences in the covered portion of the signal. The covered portion includes the BIP-X.

5.2.2.7 BIP-N $\times$ 24: B2

The 82 bytes are allocated for a multiplex section error monitoring function. This function shall be a Bit Interleaved Parity $N \times 24$ code (BIP-$N \times 24$) using even parity. The BIP-$N \times 24$ is computed over all bits of the previous STM-N frame except for the first three rows of SOH and is placed in bytes B2 before scrambling.

5.2.2.8 Automatic protection switching (APS) Channel: K1, K2

Two bytes are allocated for APS signalling.

5.2.2.9 Synchronization status: Z1(b5-b8),

Bits 5 to 8 of byte Z1#l (9, 1, 1) are allocated for synchronization status messages. Table 1 gives the assignment of bit patterns to the four synchronization levels agreed to within ITU-T. Two additional bit patterns are assigned: one to indicate that quality of the synchronization is unknown and the other to signal that the section should not be used for synchronization. The remaining codes are reserved for quality levels defined by individual Administrations.

5.2.2.10 Spare: Z1, (bits 1, 2, 3 and 4) Z2

These bits in Z1 byte and Z2 byte, are located for functions not yet defined.

5.2.3 Reduced SOH functionalities interface

For some applications (e.g. intra-station interface), an interface with reduced SOH functionalities can be used. The SOH bytes to be used for this interface are given in Table 2:

6 Physical specification of the NNI

Specification for physical electrical characteristics of the NNI are contained in Recommendation G.703.

Specification for physical optical characteristics of the NNI are contained in Recommendation G.957.

7 Frame structure for 51 840 kbit/s interface

The recommended frame structure for 51 840 kbit/s signal for use in low/medium capacity radio and satellite digital sections is given in Annex A.

TABLE 1/G.708

Assignment of bit patterns

SDH Z1 bits b5-b8	SDH synchronization quality level (QL) description
0000	Quality unknown (existing sync. network)
0001	Reserved
0010	G.811
0011	Reserved
0100	G.812 transit
0101	Reserved
0110	Reserved
0111	Reserved
1000	G.812 local
1001	Reserved
1010	Reserved
1011	SETS (Note 1)
1100	Reserved
1101	Reserved
1110	Reserved
1111	Don’t use for sync. (Note 2)

NOTES

1 Synchronization equipment timing source.

2 This message may be emulated by equipment failures and will be emulated by a multiplex section AIS signal. The assignment of the don’t use for synchronization quality level message is mandatory because the receipt of a multiplex section AIS is not necessarily interpreted as an indication of a physical failed synchronization source interface port. This assignment allows this state to be recognized without interaction with the multiplex section AIS detection process.

TABLE 2/G.708

	Optical	Electrical
A1, A2	R	R
C1	(Note 1)	(Note 1)
B1	NA	NA
E1	OPT	OPT
F1	(Note 2)	(Note 2)
D1-D3	NA	NA
B2	R	R
K1, K2 (APS)	OPT	NA
K2 (MS-AIS)	(Note 3)	(Note 3)
K2 (MS-FERF)	R	R
D4 -D12	NA	NA
Z1	(Note 4)	(Note 4)
Z2	NA	NA
E2	NA	NA
Other bytes	NA	NA

OPT Optional
R Required
NA Not applicable

NOTES

1 Optional for STM-1, Required for STM-4/16.

2 This byte will be included depending on the definite result on its use for a section trace.

3 Requires further study.

4 This byte will be included depending on the definite result on its use for network synchronization purposes.

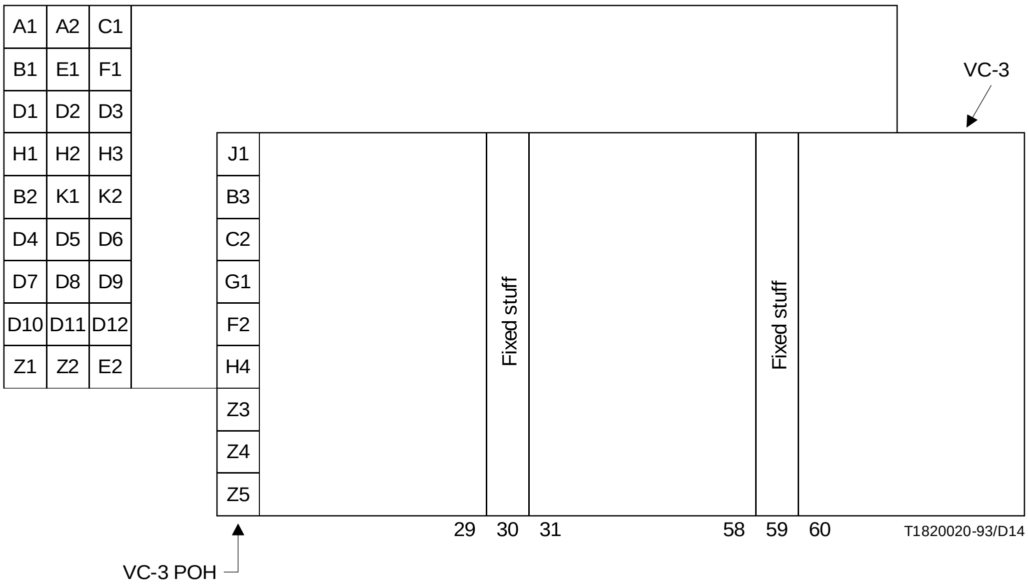
Annex A

(to Recommendation G.708)

Recommended frame structure for digital section operating at 51 840 kbit/s

(This Annex forms an integral part of this Recommendation)

Figure A-1 illustrates the frame structure to be used for systems operating at 51 840 kbit/s.



NOTE – Fixed stuff columns are not part of the VC-3.

FIGURE A.1/G.708

Frame structure of 51 840 kbit/s signal